THE PROCEEDINGS
of
THE INSTITUTION OF PRODUCTION ENGINEERS

The Official Journal of the Institution of Production Engineers

Members are requested to correspond with the Editor upon matters of general interest. Letters may take the form of descriptions of unusual plant or tools, workshop methods, production problems or organisation systems. Only in exceptional circumstances will proprietary articles be dealt with editorially. Manufacturers wishing to draw the attention of the Institution to the merits of their products are invited to use the advertisement columns of this Journal. All correspondence should be addressed to the General Secretary, Institution of Production Engineers, 48, Rupert Street, London, W.1.

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ANNUAL GENERAL MEETING.

Council Room, S.M.M.T., 83, Pall Mall, London, January 27th, 1928.

MR. R. H. HUTCHINSON, the retiring President, was in the chair at the opening of the meeting.

THE PRESIDENT, in reviewing the work of the past session and the position of the Institution generally, said that the first meeting of the Institution was held on April 21st, 1921, so that it was nearly seven years old. He confidently anticipated the day when it would become one of the great Institutions of the country, and they could not have better signified the strides that had been made so far than by electing Sir Alfred Herbert as President. One of the events of the past year was the opening of the new Section in Birmingham. There had been a Coventry Section for some time which, although small, was steadily digging itself in. The Coventry Engineering Society, which was very strong, had naturally made it a little difficult for the Coventry Section of the Institution, but it was, nevertheless, making very steady progress. The manner in which the Birmingham Section had gone forward made him almost think that Birmingham should be the natural home of the Institution.

Continuing, Mr. Hutchinson said he wished to impress on all members that membership of the Institution did not merely involve occasional attendance at meetings, and the reading of the Journal, but a duty that each individual member should do everything possible to further the interests of the Institution. The strength of an Institution depended upon the enthusiasm of its members, especially in the early days. One of the most important things was, whenever they came into contact with a likely member of the Institution, to see that he joined, because only by increasing the strength of the Institution through securing a membership of the right type, would the benefits which the Institution could give to the nation as a whole, as well as to its members, become sufficiently pronounced.

MR. A. BUTLER proposed a hearty vote of thanks to Mr. Hutchinson, the retiring President. This was seconded by MR. H. MANTELL and carried with acclamation.

SIR ALFRED HERBERT then took the chair and delivered his Presidential Address.

PRESIDENTIAL ADDRESS BY SIR ALFRED HERBERT.

Delivered at the Annual General Meeting, Council Room, S.M.M.T., 83, Pall Mall, London, January 27th, 1928.

IN doing me the honour of electing me as your President, you have violated one of the great principles of promotion that I have been preaching for years, namely, that promotion should come from the inside—that if anything happens to the Chairman of the Company you should engage a new office boy and everybody should move up one. It is singularly unfortunate that I should be made a glaring example of a procedure which is entirely contrary to my convictions. I look to you, gentlemen, to justify the choice that you have made, by doing your best to make me into a useful President, and I shall welcome all the help you can give me in that direction.

The production engineer cannot be defined very closely. His responsibilities and his scope must vary in almost every case with the particular needs and possibilities of the business with which he is associated. We should not allow ourselves to imagine that production engineers can only be afforded in very large and highly-organised establishments, carrying out mass production. I am convinced that there is scope for the production engineer in every engineering works of any importance. Very often the problems and difficulties of the small works are even greater than those of the large works, and as the engineering industry still further develops, I see endless opportunities for the growth and enlargement of this Institution.

I might perhaps have given you, to-night, a paper on some technical subject, but I thought you would rather that I addressed you on certain broader aspects of our work.

I feel very strongly on one subject in connection with which this Institution can do good work. I refer to the question of industrial accidents. Every workshop accident can be analysed, and if this is done it will be seen at once that it was completely and most easily preventable. At a meeting in Coventry the other night, a speaker from the Safety First Association gave a most interesting address and told us something that struck me with great force. I have no reason to doubt the accuracy of his statement and it was this, that the annual number of accidents occurring in industry in this country is equivalent to the number of men who were wounded annually during the war. And yet we go about our business and carry on entirely unperturbed.

For sometime past I have had every accident that occurs at my works reported to me in writing and wherever possible I have had investigations made. Broadly, I am doing what I can, but I must confess that I am unable to make the progress I should like to. The Home Office are taking up this question of industrial accidents. You know there is a new Bill which may shortly become an Act—and a good deal of attention is being focussed on this question—but I think we can do something to anticipate the effect of this legislation, by taking this question of accidents very seriously. I know no one more able than the production engineer to help in this direction. Personally, I doubt very much whether we take enough care in the teaching of our boys. I speak as one who recognised his own deficiency in that respect. I think we are inclined to take boys and put them on to machines rather hastily; that they do not have a sufficient course of instruction, and that their attention is not called to the dangers inherent in the machines they work in a sufficiently clear and patient manner. I would suggest this to you as a line of investigation. I have just had some figures from the Home Office on the subject of industrial accidents and I can give you this little comfort that the figures of accidents in the engineering industry of this country, although they are still very large, do show a marked falling off during the last three years for which the records are available.

Mr. Hutchinson has referred to the great movement for peace in industry. I think it is the most gratifying gesture that we have seen in our time. I do not expect from this Conference that any great amount of actual change in system will immediately arise, but I do recognise that the creation of a good atmosphere is the first and most important step, and in this Conference, which all men of goodwill will welcome, I see the beginnings of that atmosphere in which I hope the plant of mutual goodwill will grow and flourish. The production engineer can do much in his capacity as a buffer to ease the pressure and explain to those whom he directs that the interests of the two parties in industry are common and not opposed. I am not too sure how far the suggestion that labour is anxious to have a controlling voice in the management of industry can be carried. My experience, so far as it goes, is not in favour of management by committees, but many of the leaders of industry to-day were once workmen and have won their way to the position they hold by sheer merit, ability and energy, and the future holds similar and even greater opportunities for those workers who possess these qualities to-day.

Industrial unrest, class trouble and the like are fostered very much by memories of the past. In the early development of the industrial age in this country, mistakes were made on both sides and the employers were by no means guiltless. Things happened in coal mines and cotton mills in connection with child labour that

we hardly like to think about; but those happenings of the past—of a narrow and less well instructed age—are cherished in some memories and colour class relationships even to-day. But just as the working-man is progressing and coming along with the spread of education, so indeed is the employer learning, and is coming along, and I am confident that on the whole the attitude of the employer to-day is much more human, much more considerate, and far less grasping than was the attitude of his predecessors a hundred years ago.

I have been interested in the controversies about the relative duties of the production engineer and the designer. I think the production engineer is in a position to give the most valuable criticism to the designer. Personally, I should like to see an occasional interchange of duty between the designer and the production engineer. I cannot help thinking what splendid designers production engineers ought to make. But as between the designer and the production engineer it strikes me that the ethic of the thing is that, after exhausting his criticisms, the production engineer must give way to the designer ultimately, because the designer is responsible for the commercial success of the article being manufactured. Therefore, whilst the fullest criticism should be encouraged, and whilst it should be taken in the most kindly manner, when you come up against an absolute impossibility of reconcilement, then the designer, I think, must prevail. I do, however, feel strongly that the drawing office would benefit immensely by a recruitment from men who have worked on the production side. Many draughtsmen have gone through the shops, and I think draughtsmen generally would be helped a great deal by some experience as production engineers. I am not sure whether the production engineer would consider it promotion to become a chief designer or not, but there is no doubt that our designing departments throughout the engineering industry need stimulus. We see too many articles being manufactured in this country under foreign patents. If we had more originality and more imagination in the designing departments of our businesses, we should have less need to go abroad for ideas.

Another subject I want to mention is flexibility. I am a great believer in flexibility, not only of men but of method. It is not all of us who are fortunate enough to be engaged in mass production. With an unchanging product it is obvious that when once the best method of doing the work has been discovered, there is no great need for flexibility; but the business in which the product does not change is very rare. The only instance in which the product has not changed very much for any length of time is probably Ford's; but even this business, conducted as it is by one of the greatest brains in the world, has discovered that its inflexibility has been carried on too long and Ford must now have

spent many millions in making the complete change which has been found necessary. In an ordinary business where the production is not of that kind nor on a very great scale, the need for flexibility is very great. Mental flexibility, avoidance of the groove, willingness to take criticism and suggestion, the capacity to take broad views and to get outside one's own shop and look round the world and see what is going on; all these are very necessary attributes for a man who wishes to make progress. I take flexibility further—the shop should be made as flexible as possible. There should be no hesitation in changing plant. I am not trying to sell machine tools; you know what I mean. I mean changing plant in the sense of moving it about. There are very few shops that one goes into and walks round without seeing that in many cases the plant is in the wrong place and wants re-shuffling. Probably it was in the right place when it was put down, but the work has changed and the conditions have changed, although the plant still remains where it was. Our forefathers used to put machine tools on a big foundation, for life, but those of us who think about it now make our shop floors good enough for foundations all over except for very big machines, and with the development of the single pulley drive and the electric drive, it is no great matter to shuffle the plant and machinery from time to time. At all events I am taking my own medicine because just now I am making a very big shuffle. I am moving two works and consolidating them with another, and I am having the most interesting job of my life.

Flexibility is also very important in another sense. I think we should try to get our men flexible. I think it is a mistake that a man should look upon himself as a driller, or a turner, or a fitter for ever and ever. I welcome the man who is prepared to adapt himself to changed circumstances, because circumstances will change and only those who change with them will survive in the struggle. I was very pleased with a little thing that happened in my own shops recently. A certain job was being planed and it was decided that in future it should be milled. The planer operator was told that, unfortunately, he would not be required, because the planing machine was being replaced by a milling machine. The man, however, said: "Why should not I work the milling machine?" and the answer was: "Why not!" As a matter of fact he is doing so and doing his job very well indeed and earning more money than he did as a planing machine operator. I think we want to encourage our people to take this outlook and encourage that feeling of flexibility amongst them.

Another point which has been interesting me lately is that of transport. In connection with the re-arrangement of my works that I have mentioned, we have considered the transport problems very carefully, and I think that more attention might be paid to this aspect of works operations. We are inclined to concentrate

our attention too much on the actual cutting of chips. The best way to save time on a job is to find out if it is necessary to do it at all, and if you can so lay out your plants as to avoid transport or some of it, that is far better than getting the most efficient method of conducting your transport. By careful thought I am certain that a great deal of transport can be avoided altogether. There is nothing like confession, and I think my own case was the very worst in the world in that respect. There are three works of ours in Coventry and there is a constant buzz of cabs carrying people, or motor lorries carrying goods or coming back empty between the three works. Sometimes you will find five people waiting for the cab. The foundry, the drawing office and the pattern shop are so much apart that if a pattern maker gets into trouble and wants a draughtsman he has to make a journey of two miles. Castings from the foundry have to be carried a long distance to be made into machines and the machines, when finished, have to make another long journey to the stores and showrooms. Of course, all this is deplorable ; it has gone on for years and years, and we had not the courage to stop it. We have now taken the whole problem in hand. I commend this question of transport to you very heartily indeed, for I believe there is more scope for saving here than in any other direction.

Another subject that has been giving me a great deal of thought lately is the question of idle time on machines. Here again I am speaking of our own experience, and again I say that there is too much tendency to concentrate upon the production of chips, whilst insufficient attention is given to the avoidance of idle time to ensure continuous running of machines. If we take a milling machine, we have all been apt to measure the capacity of it by the number of cubic inches of metal removed per hour. I believe that is an entirely false standpoint and that the true measure of a milling machine is the production of so many square inches of finished surface per hour. But quite apart from that question, of producing surface versus chips, is the question of unoccupied time. Machines often wait for extraordinarily long periods. I had a report upon the percentage of idle time in the different machine departments, and when I got the report I fell off my chair ! Of course, the planing machine is notoriously idle for a large part of its time, but even with machines where you would expect much more continuous activity, the total amount of idle time is very great, and when you can save idle times on machines you will prevent the regrettable necessity for spending good money in buying more machine tools Idle time is very often a question of the supply of work. Machines very often stand for long periods because the work is not ready for them owing to one of the hundred causes which may arise. Delays occur very frequently because tools are not immediately available, because there is not a proper and easy and quick method

for the man to get the necessary tools required for the fresh job he is going to undertake. On some work marking-out causes a great deal of lost time. I know you will think I ought to be in the Ark when I talk to you about marking-out, because I imagine a good many of you do not have any marking-out at all, everything going into beautiful jigs. But some of us, even now, have to mark out and very often the marking-out is done in such a way that the man who is controlling the machine is hindered. Even those who are using jigs can give some thought to this question of idle time, because wherever the work is suitable the use of duplex jigs will help considerably; one can be loaded whilst the other is working. That will possibly reflect itself in changes in the design of machines, possibly bigger tables, greater widths, etc., and longer strokes, in order to accommodate loading jigs.

In drawing my remarks to a close, I want to assure you once more that I do appreciate very earnestly the honour you have done me, and I hope in my year of Presidency I shall learn a great deal and be a much better man at the end of the year, if I live, than I am to-day. At the same time, I want you to allow me to be of all the service that is possible to your Institution, the welfare of which I have very earnestly at heart.

Discussion.

MR. HANNAY (President of the Birmingham Section) gave some details of the steps that were taken to form the Birmingham Section of the Institution, and said he did not think any Institution in the country has such possibilities as the Institution of Production Engineers. When the Committee of the Birmingham Section first met it was decided at once that the Section was not to be a one-man show, but that everybody concerned should pull his weight and what little success had been obtained in Birmingham had been due to that fact. He specially mentioned the Hon. Secretary of the Birmingham Section (Mr. Wright), and Messrs. Armitage and Youngash, as having done good work in starting the Section. Many well-known engineers in Birmingham were joining, including tool makers and the Works Manager of the B.T.H. Co. One of the principal aims was to try and increase the wealth of the country, because that was felt to be the duty of production engineers. No apology was to be made for the position of the production man in the shop; indeed, the endeavour would be to make everybody realise that anything between the designer and the salesman was production. Care must be taken to see that the machines were properly arranged and made so that they were interesting for the men to work. Even the simplest job should be made interesting for the operator, so that he would not feel he was nothing but a mere machine minder. The want of peace in industry in the past had been largely due to lack of leadership, and he was certain that if works were properly

controlled and the leaders had vision there would not be any time for bickering and trouble. The fact that there had been so many labour troubles was a slur on leadership of industry in this country, and that point must be taken to heart.

MR. CATMUR said that he was deeply interested in the work of the Institution, which, in his opinion, had a wonderful future if it did its work fearlessly. It was evident that the influence of the Institution was going to be greater even than was thought by such men as the late Mr. Max Lawrence, and the others who founded it, and production engineers had a great opportunity of doing something for the country. One of the most important features of industrial life was the relationship between the employer and his workmen, and it would be agreed that the trouble was not always due to the workman. One of the greatest functions of the production engineer was to deal with the human side of production problems and to remove that distrust between the two sides. If only all the facts were made known so that the men would understand them, many of the troubles we were accustomed to would disappear. There was no other Institution which could make known those facts better than the Institution of Production Engineers.

MR. GORDON ENGLAND, after congratulating the Institution upon having Sir Alfred Herbert as its President, said the thing which had appealed to him most in his Presidential Address was its wide outlook. The real function of the production engineer was to deal with people, and that was a task which called for the very broadest outlook. As regards the reference by Sir Alfred Herbert that so many foreign inventions were being worked in this country, he would suggest that this was not the fault of designers. The fact was that the whole country had been allowed to sag and as a result we had the very distressing figures of unemployment which existed to-day, but that fact should make us put our backs to the wall. Frankly, he thought this old country had its back to the wall, and the result had been this desire for peace in industry which was the subject of the joint conference between employers and employed. That was a wonderfully constructive piece of thinking, but it was merely illustrative of what was going on in the minds of practically all concerned. In all shops better ways were being sought for carrying on the productive work of the country, and the Conference to which he had referred was an extraordinary signal for the future success of the country as a whole. We appeared now to be seizing an opportunity and were on the right road at last. On the question of education, he wondered if production engineers valued education at its right worth. Education in its true sense was the biggest asset of the production engineer, because if he could educate the human beings with whom he came into contact, those really effective machines and the only ones we have, then we should make some real progress. Therefore, he seriously suggested that the

education of the people in the shops was one of the points that should be constantly in the mind of the production engineer. As an example, there was the question of flexibility which had been mentioned by Sir Alfred Herbert. Indeed, he often wondered whether those who were leading the country had any conception of the enormous speed at which industry develops. Frankly, it seemed to him that they were entirely lacking in any sense of proportion in that respect. Industry was not accelerating at a constant speed, but it had a definite factor of acceleration which we did not know and could not fix. Consequently, in ten years time the change of occupation might be extraordinarily rapid. He suggested that in ten years time there might not be in existence half the trades that were known to-day, and therefore it was necessary constantly to be educating the people in the shops to apply themselves to new methods and ideas irrespective of the particular trade in which they might have been brought up. Only in that way would the workers be able to seize any job that came along. It was this type of flexibility which was necessary to maximum prosperity in production, and it was a point to which production engineers would have to give serious attention. The endeavour should be made so to arrange works that labour could be absorbed in one when, owing to seasonal fluctuations, it was not required in another, the labour returning to its original factory when the conditions changed again. That type of thing could easily be arranged between the production engineers engaged in the different factories.

Mr. Gerard Smith urged that the organisation and management of a shop was the function of the production engineer and of no other. He was the man who was able to take a chance and not to rely implicitly on precedent. With regard to idle time, no machine should be clocked off production without being clocked on idle time, because the resulting statistics were the most valuable obtainable for control.

Mr. J. G. Young expressed the opinion that the function of the designer is to co-operate with the production engineer so that what was designed could be made accurately and cheaply. With regard to peace in industry, one of the great functions of the production engineer was to teach the worker where wages come from. At present there was no organisation which attempted this. The trade union movement was formed for defence; the Employers' Federation was formed for the same purpose on the other side; but the worker had to be taught that if he was to get better living conditions he must work for them. The Institution could teach the workman much in that direction and he believed that, properly handled, the workers would be willing to help, thus increasing wages and general prosperity. A point to be remembered was that the great mass of labour was not employed on production. For instance,

if prices of iron and steel were reduced to such an extent that the production cost of locomotives was reduced by 33⅓ per cent., it would not affect the wages situation or fares, etc., in the railway world. This was a very big problem to tackle in one evening, but it was quite obvious from what had been said that there was a great deal which production engineers could do to assist in forwarding the work of the Conference presided over by Sir Alfred Mond.

Owing to the lateness of the hour, it was impossible to continue the discussion, and the PRESIDENT brought to a close what he said had been to him a very happy evening.

MODERN AMERICAN PRACTICE IN MACHINING WITH SPECIAL REFERENCE TO BROACHING AND HONING.

Abstract of a Paper presented to the Institution, February 24th, 1928, at the Council Room, S.M.M.T., 83, Pall Mall, London.

By James G. Young (Member).

PRODUCTION, a much maligned word, depends chiefly on markets and ability to adapt methods economically to meet the markets. Mass production layouts depend chiefly on ability to sub-divide operations to balance production, accompanied by rigid inspection of methods and parts produced.

Balancing production may lead to the danger of over-production, with the attendant evils of rate cutting, etc., if maximum efficiency is sought in every operation. In certain cases it is good policy to obtain the required balance by not running some machines at their maximum capacity.

The manufacturer with small quantities of a diversified nature has other problems to face, and maybe has difficulties in obtaining ideal layouts even to suit the plant installed. Frequently, however, he could, at profitable outlay, cheapen production costs by facing facts, before the markets either crowd the products out or leave a bare margin for profit. After all, profits are paramount, being a reward of service.

One machining operation which has done much to assist engineering production is broaching, which twenty years ago was confined to keyways and slots only. The necessity for quantities during the war period gave tool engineers their opportunity to investigate the production of many irregularly formed bores. Thus the changes in broaching operations to-day, compared with even 1912, are a revelation. It must not be assumed, however, that mechanical broaching is the work of the present generation of engineers, as broaching machines were constructed in England about 1854 to finish the slides of breech mechanism in Martini rifles. One of these machines at least is still in production, and exceeds in output many modern screw type broaching machines of standard design.

One of the secrets of its success is the use of duplex work heads at opposite ends of the machine, so that cutting is effected on both the forward and return movements of the screw.

Broaching Small Quantities.

Without involving a very high capital investment, it is possible for manufacturers of small quantities to cheapen an operation very considerably indeed by the adoption of broaching. An example of this is provided by the operation of cutting the slots in stator frames. In this case, which may be regarded as typical of a number of similar operations, the length of work is 18 in., whilst the diameter of the bore is 26 in. There are twelve slots, measuring 0.875 in. × 0.437 in., these being broached simultaneously by means of a set of broaches attached to a single head. In spite of the length of the work, the pitch of the teeth on each broach is only $1\frac{3}{4}$ in., the stock removed being 0.008 in. per tooth. This results in the use of broaches with a working length of 7 ft., this portion being made of tool steel welded to a 3 ft. shank, giving a broach having an overall length of approximately 10 ft.

To allow for distortion in hardening these broaches they are set out before hardening by at least 0.125 in. on a straightening press. The broaches are, of course, held up against the work by a central guiding fixture, and are pulled inwards to the minimum diameter at the outer ends by a number of radial tension springs secured to the end of each broach, and to a central ring to facilitate reloading the work fixture. On the operation shown the cutting speed is 4 ft. per minute, whilst the return speed is 7 ft. per minute, giving a total time per frame of seven minutes. An air blast is used to remove chips and to clean the fixture.

The success of this operation has led to external broaching of rotor frame slots, which are dovetailed. Several examples could also be given of heavy broaching jobs, but two or three will be sufficient to show the possibilities of the operation. At the Electric Wheel Co., Minneapolis, a rotor wheel weighing 15 tons, and several feet in diameter, is broached with dovetailed slots measuring across the widest part of the dovetail over 4 ins. No attempt was made to use a standard fixture supporting the component, but the wheels were slid into a pit and raised by mechanical jacks; the face of the wheel did not come within the face of the broaching machine by quite $\frac{1}{8}$ in. A machine known as No. 4 capacity was employed, and those who are familiar with the design of either J.N.L. or L.M.T. No. 4 broaching machines know that they will not carry 15 tons weight on a work bushing. Without going into undue detail, the possibilities of this job will be apparent when it is mentioned that the time per slot was reduced from 8 hours to 20 minutes.

Another successful large broaching job is in cutting the teeth of spur gears, the broach being made to finish one complete tooth and rough out two others. Gears up to 36 in. diameter by 2 D.P. have been cut, and where quantities are small the tooling is very economical. Obviously, the method is not recommended when the

quantity is sufficient to permit of ordinary methods of spur teeth generation, but with 15 or 20 per year broaching pays.

Another example of large broaching is a hub with a bore 6 in. diameter by 9 in. long. In the case in point, the broach is for a round hole, although for round holes of this size broaching is not really necessary. Obviously, however, where serrations are required there is no better or cheaper method. The broach referred to is built in sections, the locking collar also serving as the guide into the work.

Special Broaching Operations.

As illustrating the possibility of special broaching operations, the formation of lock barrels for Yale locks may be mentioned. The barrels are usually turned on automatics and then broached. The broaches are made in sections not exceeding 9 in. in length, and each section has suffcient material at the ends to allow stock to be ground off so that the locating holes for each section to fit into the broach body can be positive. Key slots vary in depth from approximately $\frac{1}{2}$ in. to $\frac{3}{8}$ in., according to the style of the lock. Each type necessitates a separate broach, but several hundred thousand barrels are produced from one type of broach, the first sections of which would be the same as for keyway slots, or for cutting a straight keyway. The grooves are formed on subsequent sections of the broach, until finally the full depth of the key slots is obtained. The barrels are located in a fixture which supports almost up to the cutting edges of the broaches, and a very simple cam lever locks the fixture during the operation. In the latest methods of broaching lock barrels hydraulic machines are used with fixtures adapted to locate three barrels simultaneously.

Another special branch of broaching is the production of spiral grooves, nuts, etc. Spiral broaching calls for very careful manufacture of the broaches, especially as regards chip clearance and chip breakers. Spirals with leads of one in seven and upwards can be broached by simply machining the broach to the lead required and mounting the work on a ball race so that it is automatically rotated by the pull on the broach. Short lead spirals, however, need some mechanical assistance to turn the work, to synchronise with the cutting of the broach. This is best done by gears using a shaft cut as a rack and fixed to the cross head of the broaching machine or the sliding head. This rack fits into the fixture carrying a spur gear, which in turn drives through bevel gears to rotate the work at the required speed. Spirals as fine as $\frac{3}{4}$ in. pitch can be broached, and there is obviously no limit to coarse pitch broaching.

An operation of special interest is the broaching of spiral nuts in fibre. The nuts have a length of $1\frac{3}{4}$ in. with a diameter in the bore of $\frac{5}{8}$ in., the diameter over the splines being $\frac{3}{4}$ in. There are six splines 0.078 in. wide, the lead being 1 in 20. A horizontal

hydraulic broaching machine is used with a cutting speed of 20 ft. per minute, and the production exceeds 200 per hour.

When broaching fibre particular care must be paid to the lubrication of the broach and to the cutting of the spaces between the teeth. The radius at the bottom of the clearance space must be quite smooth and free from ridges, and lubrication is best effected by wiping the broaches with an oily rag between each cut. More or less than this in the way of lubrication is likely to lead to trouble. Nuts made from 40-ton steel, similar in pitch to the above, are broached at 9 ft. per minute, giving a production of 120 per hour. High-speed steel broaches are used.

Hydraulic Broaching.

Engineers will realise that the speeds mentioned above cannot be obtained by a screw and nut action, and the mention of hydraulic broaching of spiral fibre nuts calls for some data on the subject. Before dealing with hydraulic broaching machines, however, a few instances of high-speed broaching in the production of small phosphor bronze and other yellow metal bushings may be given. The term " small bore bushings " is taken to include those from $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. diameter with lengths up to 3 in. After the customary foundry cleaning to remove as much sand as possible, broaching is the first operation, and common practice consists in removing from 0.025 in. to 0.035 in. with the first tooth. The second tooth removes approximately 0.005 in. less stock, and so on until the last few teeth remove very little more than 0.001 in. per tooth.

Push broaches not exceeding 12 in. in length are used, the shank end being up to $3\frac{1}{2}$ in. long, whilst the front end is made with a lead approximately $\frac{3}{4}$ in. long, formed like an acorn to locate the broach in the cores of bushes which may be out of centre.

In the works of the largest American manufacturer of bushings the broaching is carried out on Toledo presses at a cutting speed of 15 ft. per minute. The broaches are made from low carbon steel casehardened, an average life per broach being 300 bushings. As sometimes three or four broaches break on their first bore, due to hard cores, it is possible to take only an average life. Occasionally bushings burst, but, as the production engineer says, " these would have been no use anyway."

In the opinion of the author there is a very wide field for the application of hydraulic drives on machine tools, and a brief reference may, therefore, be made to their essential features. The Janney Willans variable-speed gear has a pulling capacity well over 2,000 lb. per square inch, and, as it takes care of its own leaks, is an ideal machine tool unit, the relief valve or cut-out being very easily adjusted. The Hele-Shaw type requires a sump or leakage reservoir, but is easier to control on machine tools than the previous type, and has much to recommend it.

The Oilgear Company is probably the most progressive concern in the sphere of hydraulic drives at present. In the last five years this company have supplied many thousands of drives for machine tools. Unlike the two types of fluid motors mentioned above, however, the drive is carried round an eccentric so that it cannot be directly driven. The pressure is obtained in a similar manner to the other fluid motors, *i.e.*, by plungers or pistons operating in cylinder barrels, and the leakage is taken care of inside the casing. The speed of the pump is 600 r.p.m. and pressures up to 800 lb. per square inch are employed. Pressures of up to 1,000 lb. per square inch can actually be obtained with a capacity of 3,060 cubic inches per minute.

A modern Oilgear broaching machine is fitted with foot control from a treadle beneath the work head. Hydraulic broaching machines of a slightly different type are also made by the J. N. Lapointe Co.

The early days of hydraulic broaching machines found the manufacturers battling with pulsation, which was due to many causes. Problems were traced variously to viscosity of the oil, leakage, the inclusion or elimination of air, compressibility or elasticity of oils, etc., and in due course were overcome. It was also found that irregular amounts of stock removed per tooth caused almost as much pulsation as air in the system ; especially was this noticeable on medium size broaches, where 70 per cent of oil pressure or the capacity of the hydraulic system was required to pull the broach. Thus, after finally producing a machine free from pulsation, attention had to be turned to the tools themselves, and, after a few years of gradual change-over, high-speed broaches found their place, and at present 90 per cent. of splines in gears and universal joints in the United States are broached with high-speed steel.

When taking heavy cuts with broaches the depth of chip which can be economically removed can be increased by taking precautions to protect the corners of the cutting edges of the teeth. If, for example, a heavy chip is taken out of a radial slot by means of a cutting edge of rectangular shape, *i.e.*, the same shape as the slot, the corners of the cutting edge are subjected to very heavy wear, and quickly break down. This is overcome by removing the corners from alternate teeth, which remove the bulk of the stock, each tooth so treated being followed by another tooth of the same overall size but shaped to the finished contour of the slot. The first tooth can, therefore, be made to remove a very heavy chip, the small amount of stock left in the corners being taken out by the succeeding tooth, which scarcely cuts at all on the top diameter.

Honing (or Grinding).

An innovation in modern production methods is the process of

grinding by what engineers in this country may wish to call honing. Honing as an operation is as old as our trade, being a question of degree in its varying applications. Going back a few years, however, one finds efforts being made to produce better pistons. According to the standards of the time these efforts were successful until a new problem was encountered in the shape of cylinder bores, which could not be finished with a degree of accuracy comparable with that of the improved pistons.

Studying the problem from this point onwards, analysis reveals two distinct sets of conditions, namely, those met with in reconditioning and those encountered in production. Ring travel wears the walls of cylinders to what may best be described as tapered and out of round. Investigation of production methods at various plants brought out other conditions which, upon superficial inspection, appeared quite different from conditions found in cylinders under inspection for repairs. New cylinders were ground by means of abrasive wheels rotated at a high speed, and passed slowly through the cylinder, the path of the wheel describing a helix. A disagreeable feature of this method is what—for want of a better name—is termed the "fuzz." This was formed at the crest of the helical grooves left by the wheel, and in running was very rapidly sheared off by the piston rings, with the result that cylinder bores quickly became oversize, tending to shorten the life of the engine.

Apart from this perhaps the most important drawback was the cost of the internal grinding operation. The machines, with very few exceptions, were of the single spindle type, and were attended by highly skilled operators. The time itself, however, was the costly item. The problem in developing a new method, therefore was to avoid the above disadvantages, and design new equipment based upon different principles, giving greater speed and accuracy at lower costs.

As the most direct route to the improvement of methods of finishing bores, the study of conventionally ground cylinder bores was commenced with the object of securing reliable data. The objectionable quality of the cylinder was the crest or raised portion of the helix or "fuzz." Chatter marks are readily recognised, even by the layman, being visible to the naked eye. The introduction of improved dial gauges and other means of inspection also revealed out-of-roundness and errors in parallelism.

Taking each case separately to determine the cause, "fuzz" obviously arises from the path of the wheel as it generates the helix, and also from the fact that the face of the wheel is not absolutely parallel with the axis of the cylinder. The wheel face develops a convex surface, resulting in incomplete lapping of one cut with the succeeding cut. Chatter marks are simply the result of uneven wheel wear; a wheel glazed on one side and free cutting on the other will chatter. When the glazed surface parts company

with the wheel, it leaves this member unbalanced. Tracing the trouble further back, it was found that the glazing of wheels on certain portions and not on others was due to heterogeneous bonding of the abrasive, or, in short, to unequal density.

The out-of-round state of cylinder bores presented a greater plurality of causes. It could result from castings with hard and soft spots or previous machining operations, whilst even locating fixtures, machines, and operators came in for criticism. Abrasive wheels ride over hard spots, whilst poor boring or reaming leaves stock, subjecting the wheels to various loads not counteracted by differentiation of normal pressures. Wear, dirt, loose abrasives, rough usage, all operate against the best locating fixtures. Rigidity of the main and sub-spindles was of paramount importance ; flexing of either meant errors. Bearings had to be as perfect as human beings could produce them, and a further difficulty lay in protecting the bearings.

Granting all these troubles to be non-existent, producers were still confronted with the human element. If the machine operator crowded the job, success was impossible. Apart from the human element, however, there are other points which must receive attention, such as the elastic properties in cast iron or steel, the loading up of the wheel face as well as glazing, and the fact that the rapid motion of abrasive wheels of varying densities charges the cylinder walls with abrasives.

The present style of grinder, as used in the United States, was developed after patient experiments with lead laps of every conceivable description and design. It was found that, by the use of properly bonded abrasives with a copious flow of paraffin, very close limits could be held. Glazing when it occurs with this process results from insufficient lubricant, or from keeping the stones pressing on the face of the work when not cutting. It is found, however, that a slight rub over the faces of the abrasive blocks with an old file removes any glazing, so that the use of diamonds or standard wheel dressing equipment is eliminated in this method.

Further, the lateral pressure on the abrasive surfaces is centralised and balanced so that the question of the stones riding over hard spots or making " window frames " around ports or depressions hardly arises. The result is an improved generation of cylinder bores with the possibility of correcting ovality or other errors in the bore previous to grinding. Accurately parallel and cylindrical bores can, in fact, be generated direct from the boring operation.

In order to demonstrate these points it was essential to construct a driving mechanism which simply consists of a wooden frame wtih steel tube supports for driving a carriage. The motor is mounted so as to permit of sprocket drive reduction to the long shaft or universal drive, and the complete unit, including the motor and

carriage, is reciprocated by means of a smaller motor secured to a bench. The second motor is attached to a driving gear giving the reciprocating action.

The complete arrangement is with a large size grinder mounted on the shaft. Actually, the size of this grinder is 17 in. diameter with a length over the outside edges of the stones of approximately 3 ft., whilst the length of the work to the ground is 68 ins. The cut is applied by means of the knurled head on the extreme end of the grinder. This operates through a central spindle on to opposed cones which apply a radial movement to the stones for putting on the cut. The attainment of accurate results with such crude equipment is sufficient evidence of the possibilities of this method. It is of interest to note, however, that in a number of cylinders, which, owing to an error, were $\frac{3}{16}$ in. under size on the diameter, the whole of this stock was removed by a grinder of this type, the average speed of stock removal, namely, 0.001 in. per minute, being maintained, in addition to which the ovality of the bore, amounting to 0.016 in., was corrected.

In automobile cylinders it may be noted that ovality is due to many causes, sometimes unevenness in the distribution of material, hard and soft spots, thin water-jackets, poor boring and reaming, etc., the resulting errors being frequently beyond the possibility of correction by the conventional method of grinding.

Another illustration of the possibilities of the new method of grinding is afforded by the finishing of a rotary valve. In this case grinding over the ports is carried out within very close limits, and no "window frames" are left by passing a plug gauge through the bores. This trouble would obviously arise when finishing a bore of this nature by ordinary internal grinding.

The limiting factor in grinding over ports, etc., with the new method is the length of the stone, and, as long as the ports do not exceed this length, there is no difficulty. Where ports exceed the length of the stones required inserts are used. These consist of pieces of material similar to that being ground, let into the ports to prevent the stones falling into the slots. In a job similar to that the inserts would be held in place by a strap along the outside of the component, or would be attached to a jig plate for bolting to the component. The necessity for using inserts does not often arise.

With regard to the length of the stones this must be determined by the length of the work plus overrun, the best actual overall length being equal to half the above total. In any event the stone length should never be less than one-third of the total length of work and overrun. On work of the above nature a limit of 0.0002 in. can be maintained.

The new method of grinding also shows to advantage when finishing two or more bores in line. Take an air compressor body.

The type of grinder has two sets of stones with a common cone assembly, and is driven from the larger end at a speed of 240 r.p.m. The reciprocating speed is 70 strokes per minute, and the cut is applied by means of knurled nuts. The larger bore is 3½ in. diameter, and both are finished positively in line to limits of 0.0002 in., approximately 0.0005 in. of stock being removed from each bore. A production of six components per hour is maintained. The great feature of this type of work is that no fixture is required. The cylinders are merely strapped down to the base face, and the bores are ground either horizontally or vertically.

Discussion

MR. GARTSIDE said he was particularly interested in honing, but not much had been said about the stones themselves. Were they held rigidly and did they feed out a certain amount in a certain time or were they worked centrifugally?

MR. YOUNG said there were cones which kept a constant pressure on the cylinder and therefore it was only possible to cut a round hole. If the hole was oval to begin with it was necessary to remove the ovality first. The actual stones were made of an abrasive of standard grades of grit and the actual method of manufacture was the same as that ordinarily used in the manufacture of abrasive wheels, but these stones did not glaze in the same manner as an ordinary abrasive wheel.

MR. HEY asked whether the stones were dead square with the bore or whether experiments had been carried out on a helix.

MR. YOUNG replied that there are both spiral and straight hones on the market, but in actual production the straight hone had been found the most satisfactory.

MR. C. N. COLLIER asked if there had been any experience in honing Diesel engine cylinder liners, and whether the author could give any information on the subject. Also, could he say the amount of material left on the liners for honing?

MR. YOUNG said that Diesel engine cylinder liners were just coming into the market from the point of view of honing. Taking a cylinder 14 ins. by 4 ft. long, if it were bored 0.01 in. the ovality could be kept within 0.005 in., and that would leave 0.005 in. to come out at the largest diameter of bored hole. One of these grinders could then be put into the bore to grind that out in about half-an-hour, and he would personally guarantee that the bore would not be more than 0.0002 in. out. There would be a length of 2 ft. over the stones, and it was necessary to run out a matter of 2 ins. at each end; therefore, there must be a stroke of 28 ins., and the distance between the stones would be 20 ins. The actual grinding noise was musical and when diminuendo was reached one knew the job was finished.

MR. HYDE said there had been a fair amount of experience with this form of grinding; it was not really honing. This method of grinding by means of a so-called hone was carried out by means of a rotary and a reciprocating motion. It was not a purely rotary motion and a good flow of absolutely clean paraffin oil was used. It was necessary thoroughly to filter the oil as it came from the job before it was returned through the pump to the job again. If that were done, a finish was obtained on the cylinder which was absolutely surprising.

MR. YOUNG said the point made with regard to using thoroughly clean paraffin oil was correct. In a 3 in. by 9 in. bore it had been found that the best speed for a 4 in. stone lengths was 240 r.p.m. and 70 complete cycles. On a 14 in. by 4 ft. bore, 60 r.p.m. and 30 complete cycles would give the correct helix. An advantage of this system over the ordinary grinding wheel was that the chatter marks were nothing like so pronounced. They were not measurable. For soft iron and soft steels, paraffin was the correct thing to use, the cleaner the better and the cooler the better. On a big job, like a 14 in. by 4 ft. cylinder, if insufficient coolant was used there would be local heating and distortion, but that could be taken out again, but not desirable practice. On one job of large size the walls were so thin that it was necessary to have an air blast travelling up and down with the grinder. In the case of hardened steel, it had been found necessary to put white lead in with the paraffin to give the paraffin some cut. In this country, however, the Home Office would not allow that combination so it had been necessary to use turpentine or turpentine substitute. In some cases where the iron was very hard, turpentine had been mixed with paraffin. That had been found to give a much better job than clean paraffin.

MR. GARTSIDE asked for some information as to the smallest diameter holes which can be done in this way. He had a reason for asking the question, he said, because some time ago he was asked to supply machines for dealing with stainless steel tubes $\frac{1}{2}$-in. inside diameter and 7 ft. long, polished. It was a bit of a problem, and, as a matter of fact, it was not done.

MR. YOUNG said the smallest hole he cared to tackle was $\frac{3}{4}$ in. There was nothing in grinding a bore any length, say 30 ft. with a 3 in. diameter bore. As a matter of fact that had been done in Providence, Rhode Island, to within 0.0003 in. tolerance on 0.95 nickel.

THE CHAIRMAN (MR. A. BUTLER) said the author had mentioned a small fibre job and had pointed out that the lubricant had a very important bearing on the job. Would the author say what lubricant he used in that particular case and whether he found it had any effect on the size of the job. Fibre was rotten material when it got damp and was that definitely allowed for in preventing the lubricant from having an effect from the shrinking point of view? Another

point mentioned by the author was with regard to bushings being dealt with by centreless grinding instead of inspection. Personally, he was very much in favour of that class of operation.

MR. YOUNG, speaking with regard to the broaching of fibre, said he had purposely rather rushed through the broaching part of the paper because he imagined that there was greater interest in grinding by honing. As regards lubrication with fibre, there was not any real lubrication. The broach was just damped with linseed oil, the more important points to water were chip clearances, chip breakers, and cutting angles.

THE CHAIRMAN said he could hardly see how it could be made moist with oil.

MR. YOUNG said an oily rag was just wiped over the back of the teeth of the broach to which he had referred in his opening remarks. If the fibre got wet with oil it would swell. With regard to the bushes, the setter spent a quarter of an hour each morning sizing the grinding wheels accurately, and that was really cheaper than inspection.

A VISITOR asked if there was any method of compensating the stones on the hones? How was it ensured that all the stones were cutting at the same time equally and cutting a perfectly cylindrical bore?

MR. YOUNG said that could only be ensured by assuming that every stone was homogeneous, but if one stone was not cutting so much as the others, it would make no difference, it would have no effect upon the accuracy of the work.

THE CHAIRMAN asked what would happen if one stone broke?

MR. YOUNG replied that it would be easily possible to carry on with one or even two stones less than the full number.

MR. RONALD asked for some information as to the material used for making broaches.

MR. YOUNG said this depended entirely upon the makers of the broach. For certain work high speed steel would be used and under many conditions low carbon steel properly case-hardened was as good as high-speed steel, but with high-speed work then high-speed steel must be used.

In answer to queries relative to stock removing, MR. YOUNG mentioned 130 Ford Co. cylinder blocks (four bores each) which he had seen ground at the Hutto Co. plant in Detroit, 400 of the bores had average of ten-thousandths 0.010 in. and 40 bores had forty-thousandths 0.040 in. stock left for grinding by honing, and using multi-spindle Hutto machine, the 0.040 in. was removed in seven minutes per cylinder block.

MR. GARTSIDE said he believed that commercial vehicle cylinders were being bored to within 0.0005 in. and he did not believe honing was necessary if the cylinders were bored properly.

MR. YOUNG said he did not think Mr. Gartside really meant what he said.

MR. GARTSIDE replied that he did because it was being done every day.

MR. YOUNG said Mr. Gartside was very lucky if he could bore so accurately, knowing the uncertain properties in cast iron, and why had companies ground cylinders at all if such excellent results were possible from boring?

MR. JACKSON asked if Mr. Young could give a hint as to broaching Monel metal five inches long and $\frac{3}{8}$ in. bore.

MR. YOUNG. How much do you want to take off?

MR. JACKSON. As little as possible to get a good job.

MR. YOUNG said that if this proposition was put up to the broaching people they would make as good a job of it as could possibly be obtained by any method.

MR. JACKSON said he was getting away with this job now and was taking a cut of 0.0002 in. per tooth and nicking the teeth of the broaches to pass the lubricant. The trouble was with the chips which seemed to weld themselves into a solid mass.

MR. YOUNG recommended Mr. Jackson to look into the chip clearance because if these were insufficient there would be trouble, as the chips would climb out. It might be that at present Mr. Jackson was simply pushing the chips back again instead of getting rid of them.

MR. JACKSON said he did not think that was so and it was a question of trying to break the chip up. At present it stuck to the tip of the tooth and came out the shape of the tooth. At the same time he was limited in chip clearances.

MR. YOUNG advised Mr. Jackson not to have so many teeth cutting and to put a few buffers between the teeth. The proposition should be put up to the broaching makers.

MR. CLARKE asked how the stones were held in the shoes?

MR. YOUNG said they were sometimes held in shoes which were ordinary metal pressings by means of babbitt metal and sometimes "shellaced." the other shoes were tool steel and pins were loose or separate from the shoes, the shoes with pins attached were termed rigid, and the tool steel shoes non-rigid.

A hearty vote of thanks was accorded Mr. Young at the conclusion of the discussion.

THE ORGANISATION OF PRODUCTION.

Debate opened by Mr. R. H. Hutchinson, March 23rd, 1928, at the Council Room, S.M.M.T., 83, Pall Mall, London.

MR. HUTCHINSON, who also occupied the chair, said that although the notice of the meeting referred to the maintenance of machine tools, and he would deal in some measure with that subject, he proposed to cover a rather wider subject.

It is obvious that when dealing with a matter of general organisation one must of necessity rightly or wrongly be governed very largely by existing conditions and too often by the legacies of ancestral managements and boards of directors. It would be impossible to deal in detail with every phase of production in one evening, so when he had outlined the general fundamentals he proposed only to enlarge upon four or five of the most interesting.

Taking an organisation as a whole it can first of all be divided into the following main departments :—

Progress ; Planning ; Plant Department ; Measuring and Standards ; Tool Stores ; Machine and Erecting Shops ; Rough Stores, and Finished Part Stores.

No system or organisation is sound which does not guard to the utmost against unnecessary delays and loss of time which are not only unprofitable but are the greatest of all causes of indiscipline amongst the operatives and consequent bad or indifferent workmanship. There is nothing more annoying to the good workman, especially when working on Bonus or piece-work than having to wait for work or material for his next job, or being hung up for the necessary tools and gauges, or when he has got going and is making good time on his job to be stopped on account of some breakdown of his machine, and it is to these important heads in the average shop that the greatest amount of lost time has to be charged.

In Planning he included the whole system of processing, rate-fixing and tooling up. When a part has to be manufactured it should first of all go to an estimator. His duty is to put down a tentative layout for the part, and approximate total machining time and the amount of money to be expended on fixtures. These particulars would depend, of course, upon the selling price of the article, the quantities in which the parts have to be made, the permanency of the design and the manufacturing tolerances allowable on the drawing. This tentative layout is then passed on to the rate fixer who would process the work in detail and fix his times and state the fixtures and tools required on any of the ordinary types of layout forms in use. This layout form together with the figure allowed for fixtures is now passed to the jig and tool designer who has two factors upon which to base his design, i.e. the time in which the fixture is to be capable of producing the job and the cost allowed for such fixture.

The ratefixer being human, naturally endeavours to improve upon the estimator's layout, as also does the jig and tool designer, and the system should be such that they are given due credit for doing so. On the other hand should it not be found possible to either keep within the time allowed for machining or the amount allowed for fixtures then the ratefixers and designers confer with the estimators, and generally it is possible to so compromise between the times and cost of fixtures as to keep the ultimate costs down to the allowed figure. Another highly important duty for the estimator is to show where group systems of production ceases to be economical and where the line system commences to pay. This is, of course, a question of the greatest importance in any shop, but far too big a subject to introduce into a debate such as this.

As its name implies the work of the Progress Department is to create the progress of all work from the issue of an order to its completion. That is to say, firstly, to see that all work is made in quantities corresponding to the orders, neither too much nor too little, and secondly, that all parts are brought through in balanced quantities to a pre-arranged time schedule.

He advocated most strongly the principle of sectional progress, that is, dividing the shop into a certain number of sections and placing a man in each section rather than having different progress men covering the whole works, but each looking after a separate class of manufacture, as it is only by such a system that work can be efficiently planned and kept track of in the true sense of progress. The system has also the advantage of relieving the foremen of all the clerical side of their work, leaving them entirely free to look after the technical side of their job, the discipline of their men, the quality of the work they are producing and the treatment of their machine tools at the hands of the operatives. In a shop possessing a properly organised progress system on the lines indicated it is entirely unnecessary for the foremen ever to have to look at a shortage list which is only wasting their time.

The sectional progress man upon whom rests the responsibility of issuing instructions as to which is the next job to go upon any machine becoming vacant should also be responsible not only for seeing that the necessary material is in readiness, but should give the tool stores at least two hours notice of the part and operation for which tools, jigs and gauges will be required. A master operation card being kept in the stores on information supplied by the jig and tool department, it is a simple matter for these to be prepared in readiness for the operator when he applies for them. The shop progress man under no circumstances should be a technically-trained man. From your chief of progress downwards they should be as devoid as possible of any technical leanings. The foreman is paid to look after that part of the work and the less sympathy he gets from the progress man the quicker he will get on top of his

troubles. He had only known two technically trained men who made successful progress men, and in both cases they were rotten mechanics.

The actual organisation or layout of the tool stores must depend entirely upon the class of production the works are engaged upon. Generally speaking in a moderate size works laid out on the group system and employing from one thousand to two thousand men, one can take it that all jigs and fixtures should be stored in sub-stores conveniently situated to the group of machines or section on which they are used. In a factory laid out on the line system, one is safe to assume that large quantity if not continuous production is handled, in which case fixtures being less frequently changed the location of the stores in which they are kept is of less importance. All small tools and workshop gauges should, if geographically possible, be grouped in a central tool store.

The stores will, of course, be sectionised for different types of standard tools such as milling cutters, drills, tap dies and die heads, but it will generally be found advantageous to bin all special tools under part number. Every bin should have a card affixed indicating minimum stocks of the various tools stored therein and a properly trained storekeeper will automatically take stock of any tool he takes from the bin and note when minimum stock is reached by flagging the bin or other simple means. Attached to the tool stores should be an inspection bench or benches and all tools and gauges returned after use should pass examination before being binned for further use. All that are worn out being scrapped, the storekeeper being notified for replacement, those needing repair or regrinding being sent to the appropriate departments after being duly recorded.

The cutter grinding section should be embodied in or adjacent to the tool stores under the control of the chief tool storekeeper. Information should be available in the tool stores at least two hours in advance of requirements and when such a custom is established at least one-third of the battle of efficient storekeeping has been fought and won. The other two-thirds are, of course, efficient checking and upkeep of tools and the sufficiency of supply.

All troubles arising in the use of tools should be investigated and dealt with by the chief tool storekeeper, and for this reason he should be a thoroughly technical, even expert machinist, and too often one finds just a clerical man in this most important job. One more point in connection with small tools. It should be absolutely forbidden for any grinding whatever of anything but standard cutting tools to be done in the shops.

Probably in nothing, unless it be the human frame, is the old adage that " prevention is better than cure " more applicable than to machinery of any kind. When one starts out to tackle the question of machine tool maintenance and repairs, the very obvious

first step is to deal with it from a point of view of cause rather than effect. The first thing to do therefore is to introduce a comprehensive scheme of recording the cause and origin of every breakdown or stoppage for mechanical fault of all machines. Emphasis should be given to the origin of the trouble because often the apparent cause is merely the result of some other defect or shortcoming in a machine, the removal of which may remove all risk of a repetition of the failure.

There exists a great dearth of men suitable for tackling the repair of a modern machine tool. This is no doubt due to the great increase in the number of machines now working on production as compared with the days before the war combined with the steady decrease of the apprentice system. Whatever the reason, it certainly does exist and not only does this state of affairs add considerably to the cost of repairs, but the difficulty in getting men sufficiently experienced to make their adjustments from the right starting point often results in ineffectual repairs and further breakdowns. Another great cause of failure is bad lubrication either from insufficient oiling or due to the use of unsuitable oil.

Another important point is that of belt drives—the right type of belt for the particular duty to be performed should be selected with great care and above all pulleys of sufficient size and width should be selected ; this often prevents the need of running with excessively tight belts with resultant bearing trouble. The ideal way, of course, is to run sectional repair men and where possible to do so, to pay them a bonus in inverse proportion to the percentage of lost time due to machine breakages on their sections. Working on such a system, not only does the man on the section get keyed up to the highest efficiency in looking after his machines, but he becomes a highly autocratic guardian against misuse of the machines by the operators, and the employer gains in the increased life, apart from increased production of his plant. In a grinding shop it is particularly essential to have machine tool men attached to the section.

The high finish and accuracy required on work at low production cost renders it entirely necessary that the machine spindles be kept up to the very highest pitch of adjustment. Spindles and workheads require frequent adjustment and slides need to be lifted periodically and cleaning and letting down. To do this it requires men specially trained to the work and of high skill who can judge in a moment the state of the wearing parts and where adjustment is required. To such fine limits do the bearings have to be set in order to obtain the best results that the usual temperatures for the bearing of an internal spindle is about 85° to 90° C., and for the wheel head bearings of a universal or plain grinder from 65° to 70° centigrade. The most suitable oil to use under such conditions is, of course Sperm oil, carefully strained and this should be

frequently removed and restrained. With grinding machines the question of belt fasteners is of the greatest importance. All belts should be, as nearly as possible, endless.

When examining the cause or origin of a failure, too much attention cannot be given to the material from which a broken part is made and note taken as to whether this breakage has been due to faulty material or to fatigue or to unsuitable material for the work the part has to do. Fatigue fractures may indicate poor adjustment of bearings or some other part of the mechanism and examination of the cause of this will probably indicate the true origin of the failure. If the fracture is good then probably a material of slightly higher specification may prevent future trouble, but in pursuing such a course care should be taken that in strengthening one link of your chain you are not merely transferring the weakest point to a very much more inaccessible or costly part of the machine. In such cases the fitting of shear pins is often a great saving.

Last but not least encourage your men to take a pride in the cleanliness and appearance of their machines. Dirt is not only frequently a cause of breakdown in itself, but you cannot expect an operator who is allowed to keep his machine in a filthy state to take even reasonable care of it mechanically. This is mainly a matter of good or bad foremanship. Get this well into the heads of your foremen and make them feel it, and you have cut a big slice off your repair bill.

It may be well to mention the importance of keeping very careful stock of all parts of machine tools calling for replacement. Service after sales is, I fear, not one of the strong points of machine tool makers and often delays running into weeks can be avoided if only a reasonable stock of replace parts is kept.

One last point : that is, accidents, their cause, effect and prevention. Sir Alfred Herbert referred to this matter in his Presidential Address at our Annual Meeting, and he mentioned the astonishing fact that industrial accidents amount to more than the casualties during the war. During the years 1914-1919, the British wounded amounted to 1,693,262 and during the six years, 1919-1924, the number of persons injured in British industry was no less than 2,385,766.

The official figures of accidents in industry during the seven years 1919 and 1925 were :—Killed, 20,263 ; injured, 2,858,821. During the same period the amount paid under the Workmen's Compensation Act was £43,051,919, and it is computed that the actual sum incurred was nearly five times that amount when loss of time, loss of output, and the many other factors are taken into consideration.

Now, as to the prevention of accidents. It is obvious that in the first place every single case should be thoroughly analysed for cause and origin in exactly the same way as that indicated for

machine breakdowns. In this connection there is a most excellent leaflet published by the National Safety First Association at a cost of 6d., entitled, "Accident Prevention Pamphlet," dealing with the various forms on which data of all accidents can be kept, and I strongly recommend those who do not already possess it to obtain a copy. One other astonishing point brought out by a study of such statistics, is that only about 25 per cent. of accidents are actually due to machinery, the balance being caused frequently by a variety of what at first sight appear to be the most trivial causes.

Chains and slings are responsible for quite a large number, due to want of maintenance, and periodical inspection, showing up excessive wear, or want of annealing or normalising to get rid of work hardened surfaces which are always liable to start a fracture. Belt fasteners are another frequent source of danger, and in all cases the belt drives should be adequately protected to prevent accidental contact. The efficient earthing of electrical apparatus either of the stationary or portable type, particularly in the case of an alternating current supply, and all metal work, which is likely to come into contact with any live parts should be bonded together and earthed. Ladders constitute a further liability and these should be of the non-slip type suitable for the particular flooring on which they are to be used. If the floor is free from water or grease a rubber non-slip device is usually suitable.

For intermittent grinding such as sharpening tools, an eye shield provided over the grinding wheel, is a valuable asset in reducing eye accidents. Periodical examination of all types of hand tools is very essential, such as reducing burrs on chisels, punches, and the like ; removing split handles on files, turning tools, etc., correct methods of fixing hammer heads to shafts with the shaft of the right proportion as regards length and strength. Spanners which have become worn should be discarded, as this frequently causes accidents through the spanner slipping and injuring the operator's hands or, in cases where the work is at high level with inadequate scaffolding, such accidents have proved fatal in precipitating the operator to the ground.

Expert first aid assistance in the case of accidents is an economic necessity both for the employer and the employee, as this reduces the time which would usually be lost in accidents due to inadequate attention, and lastly, but not least, one of the main points in connection with safety is for the whole concern, from the manager down to the lowest employee, to have the matter at heart, before any scheme can be successful. Another very important point is the good housekeeping of factories. Accidents caused through bad lighting, material left about gangways and untidy shops, are found to be much higher than those caused by the machinery, etc., and usually when a safety engineer is appointed in any factory his

first duties generally are to obtain good housekeeping and then to concentrate on guarding of dangerous machines or other processes. Makers of machine tools are now embodying the fencing or guards in their designs to a much greater extent than in the past, and they should be encouraged to do so to the utmost.

In conclusion, he urged everyone to give consideration to this question of Safety First a fair share in the forefront of their daily work, not only from the humane point of view, but on account of what it may mean to the well-being of our industry.

MR. BUTLER thought that the investigation of working limits by the measuring and standards department was a good point, but he was wondering whether a lot of that should not be done before the work gets absolutely into production. If the limits were set as nearly as possible in accordance with the quantity of production, there should not be much investigation for the measuring and standards department to do, unless it were found at times that the limits set were too wide. There would always be occasions when there had been miscalculations. As to the estimating department making a tentative lay-out of the operations in the first place on a new job, he was wondering whether the estimator was the right man to do that, because he felt that that particular function was the function of the production engineer, and he further thought it was very much better carried out by a small committee consisting, say, of the production engineer, the chief draughtsman, a representative of the inspection department and possibly the tool room foreman. That should save a lot of time. In that way, it would be known before a job was put into progress whether it would stand a certain price or not as all the departments concerned could be consulted beforehand. Although he regarded the inspection bench in the tool stores as a sound idea, he himself had never yet been successful in working it. It generally meant that quite a lot of tool stores were transferred to the tool room and remained on the bench there and waited until they were wanted again. Perhaps it was due to the scarcity of really good tool repair men. He thought they had themselves to blame to some extent because sufficiently good pay was not forthcoming.

THE CHAIRMAN said it was very easy to lay it down that the limits should be fixed before the part goes into production, but it was equally easy to say that that did not always pan out, for the reason that there must be give and take on tolerances. It was common knowledge that there was a tendency for small errors to accumulate and eventually a point was come to where the functioning of the part was affected. It was the investigation of these questions which should be carried out by the measuring and standards department. As to the estimating department preparing a tentative lay-out, that was merely a name, and he had often tried to think of a better, although he had not been successful. The

function of the estimator was to take a part and estimate what it could be produced for and what amount of money should be allowed for fixtures. The estimator would be in possession of information which it was not always politic to circulate to a committee and once again he must express the opinion, as he had done on so many previous occasions, that he was totally opposed to committees because he had never known any committee on works organisation do any good. If every man was given his job and made responsible for it things went much more smoothly than if there was a committee, because immediately a committee was formed there was argument and dissension or else some members of the committee agreed with things which they really did not believe in simply to save argument. As to the inspection bench in the tool room, he had never found any difficulty in this.

As to the dearth of machine tool repairers, he believed that if the system could be universally adopted of paying these men a fixed amount in inverse proportion to the percentage of lost time through machine breakages on their section, the right type of man would be attracted for that job. At present they were usually paid fitters' rates. He should like to see such a system become universal. The practical abolition of the apprenticeship system was a very important matter in this connection and one which the Institution should tackle, because undoubtedly the industry would suffer in the future through lack of suitably trained men.

Mr. Young said that whether a firm should have all the departments mentioned by the Chairman, depended very much on the size of the undertaking. He did not think, also, that the storekeeper should be a technical man, but he should be a man who was trained in providing a flow of work to the shops or to the rough stores department, so that everybody would know where they stood. There was no doubt that the repair question boiled down to a matter of wages, whilst as to the apprenticeship question he believed we should have to wait another ten years before there would be a live interest in it. In years gone by, this matter was one of father and son, but in recent years the skilled man in the engineering trades had been treated so badly and obtained such poor money that there was a strong disinclination for him to put his sons into the same work. The Chairman had referred to machine tool salesmen and the giving of service after the machines had been bought. Unfortunately many of the suppliers never thought of spare parts, and if they did the charges for them were extremely high. The result was that very often the users made the spare parts themselves perhaps ultimately to the detriment of the machines and that was a matter which needed investigation.

The Chairman said he did not suggest that his organisation lay-out would apply absolutely to large and small firms alike, but in general principle it was the same. In many cases perhaps the

departments would resolve themselves into one man departments. With cheap production, however, rigid inspection was essential and that was a fundamental principle. Mr. Young was wrong in thinking that the suggestion was that the chief store keeper should be a technical man. He was referring merely to the chief tool storekeeper.

MR. YOUNG :—I agree.

MR. SALMON suggested that the measuring and standards department should be amalgamated with the inspection department under the term of the inspection and investigation department. What was wanted in many cases was a stronger link between the assembly department and the inspection department and an efficient inspection and investigation department under a fairly efficient head would avoid many troubles which now occurred from time to time. There were firms both in this country and in America which had worked on this plan for fifteen years, although generally speaking nothing was heard of an inspection and investigation department in this country.

THE CHAIRMAN said he was glad this question of the measuring and standards department had been raised, because it was almost a new departure for this country. His answer to Mr. Salmon was that the inspection department should not in any way come into the production department, as it must do under Mr. Salmon's suggestion. The inspection department should be a department whose business it was to check manufacture in all its phases as regards dimensions against the drawing, but directly it was brought into the production department the need for production must influence the work of the inspection department. As regards the suggestion that it would be useful for the inspector to understand methods of producing a part in machine operations, his own experience had taught him that the worst possible thing that could happen to an inspector was that he should begin to take an interest in, and meddle with the manner in which the part was produced.

THE CHAIRMAN in bringing the meeting to a close said that the point to be borne in mind was that organisation should be so planned that the work was covered in the right department and that each department functioned correctly through the liaison between the different departments.

A hearty vote of thanks was accorded to the Chairman at the close of the discussion.

THE TREND OF MODERN PRODUCTION METHODS.

Abstract of a Paper presented to the Institution, April 25th, 1928, at the Council Room, S.M.M.T., 83, Pall Mall, London.

By E. W. Hancock (Member).

IN examining the trend of modern production methods with a view to further progress along sound lines, it is sometimes advisable to review past experience and, where possible, benefit by mistakes. Going back only seventeen years, there is no question that there was a definite line between "master and man." There was little appreciation of each other's problems, and few exchanges of ideas, the one issuing instructions, the other having to carry them out—often under very difficult conditions.

Universal machines were the rule, the machinist frequently having to think out and make his own tools, whilst the fitter had to fit each individual piece. If work was urgent a progress system was used, which relied more upon an eloquent flow from the engineer's vocabulary rather than upon any sound or pre-considered plan.

Small quantities of articles were made in this way, but working conditions were bad, and reliance was placed upon highly-skilled workmen. It was then found by the men that if more than one of a given piece were required, a simple rig-up with a fixed set of tools gave a more consistent product in a shorter time. From this the jig and tool man emerged, but his work in many cases was unsystematic, and frequently regardless of operation sequence.

The next step was to plan and process work, indicating the sequence of operations and types of machines to be employed. The jig and tool man was also withdrawn from the shops, and was expected to design complete jig and tool layouts from the component drawings, however bad, with little or no opportunity of discussion with the designer, or knowledge of the company's policy.

Following this, the tendency was not only to plan operation sequences, design jigs and tools, etc., but to estimate times and costs, including initial cost of equipment, before any work was carried out. In all these stages there still existed a trace of the original dividing line between "master and man," but it will be observed that the jig and tool man was taking up an "in-between" position. He had to consider not only the manual workers, but also the company's policy. As is usual with any "in-between"

position, the individual responsible was frequently in bad favour with both sides, but in spite of this the efforts made showed marked progress in production methods in the form of improved and increased output at less cost on a given floor area.

The above outline covers the extent of the progress made by many works in this country even up to the present, and it is from this point one should look ahead. To indicate, therefore, modern tendencies, it is felt that something more is required from the "in-between" man than merely processing, jig and tool designing, something far more comprehensive and binding between the "master and man." In this field there is ample scope for men able to understand a company's policy and to convert an estimate and, more often than not, a hope, into an actual fact.

In this capacity also rests the possibility of using the workers' efforts in the most fruitful manner for all concerned, with increased profits to owners and workers alike. Men in this capacity have come to be known as production engineers, and it is the endeavour to show how these men can render the greatest service to a company and, given proper opportunities, introduce modern production methods.

Subject to satisfactory designing and specification, economic production of the future will depend upon planning, detail processing and machinery, these three factors being considered in the broadest possible sense.

Planning must be carried out by flexible minds, open for sane discussion, quick to sense criticism, and prepared to work in the open, so that a satisfactory response will be forthcoming to any type of sound policy or workshop query. Such tendencies, however, should apply throughout an organisation. Directors should know their staffs; designers should exchange theoretical with practical ideas; accountants should re-arrange their figures so as to supply costs immediately in an easily understood form. It is only when conditions such as these exist that general progress is likely.

Planning.

In order that a production scheme may be put forward in a manner likely to carry conviction, it must be considered broadly and from every aspect. To plan such a scheme as a whole, however roughly, will render a more uniform and complete result, and allow for an appropriate disposition of capital. Such a scheme in connection with a known product should include:—

Types of buildings.
Floor areas.
Disposition of functions.
Services, such as power, heat, light, compressed air, etc.
Flow of work, from reception of the raw material to the despatch of the finished product.
Approximate disposition of machines.

Approximate disposition of tool services and tool cribs.
Internal material handling.
Approximate costs of buildings, services, machinery and equipment.
Approximate periods for completion.
System of accountancy and payment.
Approximate cost of product.

All such work can be planned, based on the experience of consultants, but should not be worked out in detail by one man. Every possible freedom should be given to the men collecting this information, to mix with executives not only of their own company but in other concerns.

No man is able to plan on these broad lines if confined always to the narrow limitations of any one office. Work thus carried out may be good in its conception, and the effort exerted beyond reproach, but when put to the test the desired result may not be produced, as the broad issues involved can only be assimilated and appreciated by widely experienced minds. Further, the mixing habit results in a quicker attainment of satisfactory results—an important factor in these days of fluctuating designs.

Shop Buildings.

Dealing with the buildings which are most satisfactory for workshops, three main types should be considered. First there is the single-storey building, which has much to recommend it, especially for a flow system of production. It has obvious advantages in material handling, since the cost of lifting material is saved. This type of building also gives better natural lighting. Against it, however, is the cost and the fact that it does not make the maximum use of the ground area.

On these points a multi-storey building has an advantage, and of the two types of multi-storey factory the open or well-centre building has an advantage in giving better general daylight and observation, with the opportunity of moving materials from floor to floor within the well at any desired point. A single-storey building, or one of the multi-storey type with a well centre, should therefore be considered first, and either may be so arranged as to give equally good results.

When planning floor area and disposition of functions, flow charts are necessary. It is important that these should be made out to show the main flows of material, as there is here a possibility of great economy, not only in more efficient operations, but in minimising the quantity of material in process.

From this point planning takes a more definite turn, and for this reason a final decision should not be made until every conceivable system of material flow has been considered.

In estimating floor areas, the average area per machine or

assembly should be taken. As an example, a fair average, allowing for liberal gangways, is 90 to 110 square feet per machine. In apportioning floor areas the product must be allowed to progress in the most natural manner, placing operations, irrespective of their nature, in the best sequence. This is an ideal which, however, can be achieved with modern equipment, even to the inclusion of heat treatment processes.

Material Handling.

Methods of material handling should be planned in conjunction with material flows, as one is definitely dependent upon the other. Opinion is divided on this question, some favouring a mechanical conveyor, whilst others prefer the trucking system. The conveyor has definite advantages, especially when dealing with bulky articles, but it is less flexible than the trucking system. A combination of both systems is suggested.

In moving heavy components from one machine to another, there are two main methods—either the jig containing the component may be removed on a truck or a roller conveyor used along the line of machines. The first method, although having certain advantages, has many disadvantages, the chief being that apart from a complicated jigging system, non-standard machines are usually necessary. There is a sane tendency towards the use of special but standardised machines of a simple nature, and the slight loss of efficiency due to movement of material on a roller conveyor is easily outweighed by the advantages to be gained.

In the early stages of production it is inadvisable to be tied to one system of conveyors, as sufficient flexibility for machine re-arrangements is desirable.

For all assemblies, a mechanical conveyor invariably pays for itself and should be installed as, apart from assisting the workmen, it has the advantage of acting as a quantity per hour gauge, the speed being set accordingly.

The question of tool services is important and should receive early consideration, being planned in parallel with line or section planning. A maintenance tool room should occupy a reasonably central position, but tool cribs should be placed as near each line or section as possible, all being controlled by the central main stores. Daily or even hourly checks of these tool cribs should be planned.

Design and Production.

Regarding the influence of production on component design, it is thought that any new design should first be quickly rough-planned to consider the main principles of production, and possible modifications to facilitate production. The argument that quantity production, or mass production as it was called, gave a cheap and nasty article, is dying a natural and well-deserved death, and it

is now recognised that scientific quantity production reduces the price and gives a better product.

Modern production does not start in the machine shop, but commences with the first conception of the product. Two distinct aspects should be fully investigated before production in quantity is planned. The first is experimental and research design in which the designer checks mechanical efficiency, based on tests, and his estimates and calculations. The second aspect is the design of units and components for accurate and economic production. Often the public have to pay for lack of the second in initial payments and lack of the first in annual payments, but a sane combination of the two gives the public the best ultimate value. Research design usually carries more complications than production design, but many such complications may be removed without detriment to efficiency. This process of eliminating complications is leading to a new school of design, in which simplicity with efficiency is the keynote.

During the rough planning of a product it is important that all possible methods of machining, types of machines, etc., should be considered in connection with all major components. This is necessary to take advantage of the rapid advances in machine tool design which are being made daily. Machine tool makers who make a point of studying and understanding the users' point of view are advancing in front of much older established firms, and can submit acceptable proposals. During rough planning, blue-prints of components should be circulated to machine tool makers for this purpose to obtain prices, times, floor areas, etc. It is during this period of rough planning that open discussion regarding types of machines or a particular machine should be made. Final decision regarding any type of machine should be left as late as possible, as the stronger the discussion is when the mind is unfettered, so will the argument of justification be easier after the machine is installed.

Installation of Machines.

This point is important and needs to be planned well ahead, otherwise dislocation and confusion is likely to occur. Machines should be working as quickly as possible after receipt to avoid idle capital, and a good plan of action is to make machine location plans showing the exact position of machines. With operation sheets drawn up on broad lines, the earlier operations can then be tried and proved in sequence. Objective dates issued in chart form, indicating dates on which certain machines or lines should be running, are also important. Provision must be made for balancing up after preliminary tests of lines and sections by allowing space for additional machines if necessary.

Detail Processing.

The planning department is already appreciated in this country,

and the tendency is to make greater use of this department, which is a step in the right direction. The department must be organised to deal with all planning, including tool, gauge and die designing; to carry out investigations, demonstrations, time studies and have control of the tool department and tool stores. The staff should also include specialists in particular branches of the trade. As much information as possible regarding the company's policy should be given to the planning section.

The tendency is to remove from the jig and tool designer the responsibility of processing, leaving him free to design equipment within the boundaries set up by the planning section. All men on a planning department staff should be given the greatest possible freedom for broadening their experience. Free access to the shops is necessary, and any new features in any particular lines which come to light should be passed on to the juniors. A broad view should also be encouraged in the younger members of a planning department.

Another important question for the planning department is that of samples of raw material, particularly when stampings and castings are brought out, so that machining allowances, jig locating points, etc., can be studied. This matter reveals the importance of studying ultimate costs rather than first costs and of buying from suppliers who are able to appreciate the requirements of machining and assembly.

Assembly.

In the detail processing of assemblies careful consideration should be given to the mechanical type of conveyor. Where the flow principle is adopted a certain base time for the cycle of operations is necessary, especially if the ultimate product consists of a large number of parts. The output of the assembled products depends upon the production of each component within this base time. On the flow principle lapsed time is difficult to recover, consequently conveyors correctly timed are useful in checking the flow of material.

Wood parts should be dealt with on the same basis as metal parts, although the saw mill presents a difficulty, as a large volume would be necessary to employ permanently set-up machinery. Even with a moderately high output the batch system of working in the saw mills is still necessary, but even here the machines may be arranged in the natural sequences of operations on certain classes of timber to be sure that the material travels the shortest path. Efficient jigging systems can be introduced on assembly both for wood and iron.

In arriving at the base time the projected output per week should be divided into the proposed number of working hours per week to obtain the complete cycle of operations. The time so arrived at, however, should be increased to give a margin of safety, to

cover scrap, and the production of spare parts. Having established the base time it must be constantly referred to in detail processing to check the loading of every machine. Optimism at this stage is fatal, and it is recommended that such work be kept strictly within the set base time.

Before advancing too far with detail processing, schemes of machine grouping should be investigated. Whether in a line or the inevitable section, the best disposition of machines must be studied, so that units are completed in a particular area. This grouping of plant also affects the system of payment, especially when men are paid on the Group Bonus plan. During this work of machinery grouping, the time-study men of a planning department should be consulted.

Sub-dividing Operations.

There is a marked tendency towards increasing the number of operations for any given component. In the past the combination of too many operations was attempted, the same tooling being expected to perform roughing and finishing operations.

For production in large quantities every step in detail processing must be as definite as possible. This entails a much closer study of the manufacturing steps. Taking a cylinder block, one of the worst troubles with monobloc castings was that due to distortion. Much time and money was spent concentrating on three operations, i.e., boring, reaming and grinding, whereas to-day, in machining similar castings, it is found that, by splitting up the operations in the correct manner, a consistent product is obtained without trouble.

In producing a piston bore, the following operations should be considered. Stock removing; straightening the bore in relation to the plane of the locating face; rough sizing the bore; finish reaming; and honing. Certain of these operations can be combined, but the tooling should be arranged to safeguard each one.

Further examples of splitting up operations can be found in handling any fragile component which has to be accurately ground, e.g., pistons. These should be rough and finish ground, or in certain cases rough ground, semi-finish ground, and finish ground. This splitting up of operations again allows for an even distribution of values, as accuracy can be safeguarded on the finishing machines by attention to the previous operations.

In equipment designing the tendency is towards greater efficiency and simplicity. Over-elaborate jigging systems are dying a natural death—plain, straightforward and robust jigs rendering the best service. This tendency runs parallel with the sub-dividing of operations, with the result that simpler designs are possible, especially on permanently set-up machines.

Multi-jigging is rightly coming into favour, and double loading of jigs is no longer a novelty in this country. This method is to

be encouraged, but only on standard index tables of the two or three-position type. A three-position table for drilling and reaming is entirely satisfactory.

Tools are also becoming simpler with greater provision for quick replacement and setting. Gauging methods have advanced considerably to keep pace with the fine limits necessary and obtainable on modern machine tools. Increased facility in making accurate readings is provided by dial gauges, fluid gauges, and approach gauges during grinding.

Machinery.

A correct disposition of values in machine tools is only possible when the machines are appropriate for the components to be produced. Even in the most modern shops, either in England or America, there are, and always will be, certain simple operations which call for simple but good machine tools. It is important that production engineers do not let their practical tendencies lead them towards installing highly productive or novel machines, unless they are to be used in their fullest capacity. A machine tool is a means to an end, and should always be regarded as such.

The tendency is to shorten manufacturing programmes, and the time allowed for re-equipping a works is becoming shorter, emphasising the importance of accurate deliveries of machine tools. This is a question that needs far greater attention by machine tool makers, as frequently machines are purchased merely because delivery is likely to be reliable. Further, business frequently goes to a foreign country because this question is not appreciated by British machine tool makers. American machine tool makers have had experience on this point, and recognise their responsibility as regards delivery dates.

Machine Tool Service.

A further and sane tendency is for machine tool makers to undertake equipment and special tool design with a machine for a particular operation. This has many advantages to all parties concerned.

When asking machine tool makers to design and make special equipment for a machine tool. however, it is important that they receive not only component blue prints, but also detailed operation sheets, and if possible, jig and tool arrangements for prior operations. This also shows the importance of machine tool makers having first-class production engineers on their staffs, to assimilate users' requirements, and assist in giving a sound response to inquiries.

This leads to the important question of machine tool salesmen, as there is no doubt that much business is likely to go out of this country if qualified technical men are not employed. The old

fashioned method of salesmanship, more often than not criticising other makes of machines, should be altered as quickly as possible. There is a slight tendency in the right direction which, however, must be stimulated.

The purchase of a machine tool is usually affected strongly by the initial discussions and quotations. For example, if a description of a manufacturer's requirements for a particular operation is given, and a quotation requested from two or three machine tool makers, and it is clear on receipt of the quotations that the manufacturer's requirements have not been understood, this is the first step towards loss of business.

The ideal form of quotation, from the user's point of view, is the three-folder type independent of any covering letter. In the centre of the folder should be the reading matter covering the basis of the contract, with definite descriptions of the machine and guarantees. On the left should be a photograph of the machine, and on the right of the folder prints of the special equipment arrangement. Such a quotation is not only easier to read and deal with, but inspires the user with confidence. It cannot, however, be put forward unless, as previously stated, men with production knowledge are at the back of it.

Another important question is the demonstration of machine tools by the makers. The responsibility of machine tool makers should be carried until the machine has been demonstrated and proved in a user's works. This should be part of the contract, and it gives the machine tool suppliers the best opportunity of proving the claims made regarding their particular machine.

In American shops it is a usual sight to see numbers of machines being operated on production by the machine tool suppliers' men. This again removes the responsibility from the users, allowing them to concentrate on work for which it is impossible to obtain other assistance.

Machine Tool Design.

A good margin of safety is necessary in machine tools, both in rigidity of construction and estimated output. Descriptions and photographs of large cuts being taken on machines, sometimes surrounded, or partially covered with swarf, are quite common, but often on inquiry it is found that no quick return of table or saddle is incorporated in the design.

As previously stated, a machine tool is a means to an end, i.e., to produce components to a required standard in the minimum of time. Consequently, the user is more concerned with floor-to-floor times than with the magnitude of the cut.

The machine designed to eliminate idle time, even though its cutting capacity may be less than a competitive machine, is a better machine if it gives a lower floor-to-floor time. The latest machines

combine both qualities of heavy cutting and quick operation during idle periods.

A further tendency is towards independent motor drives. This is most important, as it facilitates line production, the placing of machines in any required position, and general flexibility, also unnecessary mechanism is dispensed with owing to driving motors being closer to the final driving spindles.

Standard Machine Tools.

There is a strong and sane tendency towards the use of standard rather than special purpose machine tools. Production engineers should bear in mind that within reason the shops should be flexible to deal with different designs of the same class of product, with a reasonable expense in modification. Even in this country grave mistakes have been made in the installation of absolutely specialised machines for a particular design of component. It is considered unsound, on the one hand, to tie designers down to a specific design or, on the other hand, to commit a company to unnecessary expense.

A special-purpose machine usually takes longer to design and make, suffers from lack of trial, rarely carries standard replacements and is more often than not a source of worry to all concerned. Economic production regarded broadly can be achieved with standard, well-tried machines equipped to serve a semi-special purpose. For instance, in the case of a standard machine equipped with a special boring head, all that is required to modify the machine for dealing with a different size or number of bores is usually a change of head. If a breakdown occurs on a standard machine, replacements are easily obtained, or in an extreme case the complete machine can be replaced.

A further point of no less importance is the time element, as the manufacturer who can most quickly put into production a more modern design is most likely to lead the field.

Conclusion.

From the foregoing it will be seen that the production engineer is in a position to render the greatest service to the industry as a whole, having a variety of problems to solve and fit together so as to achieve manufacturing efficiency, and thereby overall efficiency of the company. In view of the great responsibility that is thus placed in the hands of production engineers, it is necessary that the best possible opportunities be given them for widening their experience. Great emphasis is laid upon the importance of travel, and the opportunity of mixing with other men throughout the country, so that exchanges of ideas may be made, the country as a whole quickly reaping the benefit.

The production engineer of the future must not only have knowledge of true engineering production, but also of all the major

functions which form a satisfactory business organisation. He must set himself objectives for the large variety of work which he has to handle in a given time. To shoot at a target, however small, gives precision of action, which is a most important virtue in work having so many variables.

Costs must continually be considered, and there is no question that organisation of the future will find it necessary to employ engineering accountants capable of giving figures which form the background of economic production. For a production engineer the three most important virtues are considered to be, knowledge of engineering production as such, knowledge of distribution of values and an open mind.

Discussion.

MR. HUTCHINSON said quite frankly that he was somewhat disappointed with the paper. Knowing of the great things which Mr. Hancock had been doing during the last twelve months or more, and of the unique experience which he must have had, he had expected that Mr. Hancock would have discussed some of the difficulties he had experienced and the means by which he had overcome them. Mr. Hancock appeared to be too much obsessed with the idea that the work—certainly very wonderful work—which had been done by modern motor car producers was the beginning and end of production engineering.

There seemed to be a tendency to assume that production engineering meant merely the production of small parts, generally motor car parts, but it embraced also the production of such things as steam turbines, gas engines, locomotives and even ships. Mass production was only a very small part of production engineering. He did not suggest that there was not a very considerable amount of engineering involved in the manufacture of motor cars, but he did suggest that in discussion such as this the real engineering side of the subject was glossed over, to the detriment of the technical side and the furtherance of the purely progress or clerical side and perhaps the planning side. He supported heartily Mr. Hancock's advocacy of the independent motor drive for machines, and said that the machine tool makers could do the production engineers a very great service if they would develop the independent motor drive. Incidentally, he mentioned that the President, Sir Alfred Herbert, was offering a prize for the best paper given by a member of the Institution next session on the individual electric driving of machine tools. Another matter in regard to which Mr. Hutchinson was in agreement was Mr. Hancock's advocacy of the standard tool. The purely special purpose tool, he said, had proved itself of no use except for very special classes of manufacture. That lent weight to his suggestion that it was not for the production

engineer to send his drawings to the machine tool manufacturer and to allow the latter to decide what machine tools should be used.

MR. HANCOCK, replying to Mr. Hutchinson, pointed out that his paper was entitled "The Trend of Modern Production Methods" and was not a paper on his (Mr. Hancock's) difficulties. Mr. Hutchinson seemed to object to the fact that cylinder blocks and pistons—being components of motor cars—had been referred to, but it must be remembered that such parts are universally used, not only in motor cars, but in aeroplanes, etc. Mr. Hutchinson also seemed to object to the principle of sending blue-prints to machine tool makers, but it was clear that Mr. Hutchinson had not been faced with the problem of producing quantities of articles at a particular price, in a limited space of time, and until one had entered this somewhat hectic realm of producing components economically in a short period, one could not appreciate the large mass of detail involved. With regard to the selection of machine tools, he had pointed out in his paper, that the final decision regarding the actual make of machine was the responsibility of the production engineer, but that blue-prints should be sent to those machine tool makers who were likely to produce the best machine for the work, and in order that they—with their knowledge and experience—might assist the production engineer in coming to his decision; all this work requiring first-class technical knowledge.

MR. WILLMOT said that a point which had not been emphasised sufficiently was the value of standard sheets in production. These were very valuable guides in the cheapening of production. Another important matter was that of the efficient handling of stores, for a great deal of money could be wasted or saved in this connection. Recently he had seen what was practically a stores on wheels. It might not be possible to apply such a system when one had to store heavy parts, but the stores he had referred to contained small and light parts. All the bins, nine standard partitions, were on wheels and in a short time the position of the stores in the factory could be altered, so that they could be situated in the most convenient part of the factory for any particular stage of production. He advocated the use of the single-purpose machine. Until a few years ago a certain factory which was devoted entirely to the production of commercial motors and dynamos up to about 100 h.p., had used standard machines. Following his suggestion that single-purpose machines should be used instead, the merits of single-purpose and of standard machines were studied in relation to the particular operations which had to be carried out, and at present, as the result of that study, the factory was run on single-purpose machines. Certain standard machines were used in some of the shops, but very few were used in the production of the work. He expressed the view that some of the larger works in the country to-day would be well advised to design their own special tools, for

it was his experience that that was a paying proposition. The method of remunerating labour was an important factor on the production side of engineering to-day; there were many methods which could be applied, and there were many points for discussion as between the straight piece-work and the premium bonus systems. The time element was another important matter to which Mr. Hancock had not given very much attention. It was the tendency nowadays for boards of directors to decide that a certain article was to be produced and that it must be on the market within a certain time. That limited the production engineer to a certain extent in the planning of production, and very often a production engineer, if he had sufficient time to consider the matter properly, would lay out his factory to greater advantage than he could do if his time were limited.

Mr. Hancock said that he agreed with Mr. Willmot's remarks as to the value of standards, and of proper stores organisation. The tendency, however, should be to minimise stores as much as possible. One often found so-called production engineers spending much time and money in saving half a minute on a five-minute machining operation, yet at the same time, paying no regard to the possible saving in material handling and material flows. He agreed with Mr. Willmot's remarks concerning single purpose machines up to a point. He said, as mentioned in the paper, let there be single-purpose machines, but let them be universal for that single purpose, so that in the event of the design being slightly modified, the machine could be modified accordingly. He knew of cases in this country in which engineers had installed absolutely special-purpose machines for a particular design, and even with the slightest alteration to that design, the whole value of the machine was nullified. Regarding the remuneration of labour, he pointed out that he did not propose to discuss all possible systems, but he regarded one of the best methods of payment as being what is known as the group bonus system. Under this system, men work in groups of six, eight or ten, and are paid on the basis of the output of the group, the bonus being spread over the whole, so that the cost of the product is constant, but the possible earnings of the men unlimited.

Mr. W. E. Gannon defined a production engineer as one who could, from the drawing of a component and a knowledge of the material to be used, time and cost that component to a great degree of accuracy. That was the type of man that our manufacturing concerns needed more of. It had too long been the practice to ask the machine shop foreman how long it would take to do a certain job and to fix the price on that basis. The production engineer would deal with the matter scientifically. If it were a component which was to be manufactured in quantities, he would not go into the shops in order to see where he could put it, but would decide upon the right kind of machines and equipment to be used for its

production, and he should produce it in such a manner that no other firm could do it better, or at lower cost. He asked for Mr. Hancock's opinion as to whether, if a manufacturer received an order for 100,000 of a certain component, to be delivered in batches of 1,000 per week, it would be more advantageous to manufacture them all at once (having set up the necessary equipment), and store them, or to produce them in batches. With regard to independent motor driven machines, he said his experience was that the small motors used on the small machines were not so reliable and efficient as the larger motors used on the larger machines.

MR. HANCOCK replying to Mr. Gannon, as to whether it would be better to produce 100,000 parts at once, store the finished parts, and deliver in small weekly quantities, or to produce parts in batches of say 1,000, and purchase material in smaller quantities, said that this was entirely dependent upon the organisation of the firm dealing with such work, and was entirely a question of cost. If, for instance, the parts were made of some valuable metal, it might be better to increase the direct labour cost by manufacturing in smaller batches, and so avoid investing large sums of money in idle material, whereas on the other hand, if the parts were made of inexpensive metal, it might be more economical to reduce the direct labour cost by manufacturing the whole of the 100,000 parts at once, and to store them. With regard to electric motors, he said that it may be that small motors were not so reliable as large ones, but if one used a large motor to drive forty or fifty machines, and that motor broke down, all those machines would be idle, whereas with one small motor, driving one machine, breaking down, only that one machine would be idle. If most of the machinery in a shop was driven by belts, it may then be questionable as to whether only one independently driven machine should be installed, instead of putting another pulley on the shafting, but in his paper, he was making a direct comparison between a shop using all independent motor-driven machines, with a shop using all belt-driven machines. He agreed that an adequate supply of spare motors or motor parts should be carried. The efficiency, durability and reliability of electric motors was advancing just the same as the other branches of the engineering trade were advancing.

THE CHAIRMAN (MR. A. BUTLER) urged that the manufacturers of motors and machine tools should co-operate in the development of the independent motor drive, and he advocated a greater degree of standardisation, in such matters as spindle heights and armature speeds for instance, so that if one were using even half a dozen different makes of motor one could carry standard spare parts and would be able to reduce the stocks of such parts. The duties of a production engineer must depend largely on the size of factory with which he was concerned. In a large factory he could not possibly do all the detailed work he would be expected to do in

a small one, and in a large factory he would have a suitable planning staff. He saw no objection to a production engineer submitting designs to machine tool makers when he wanted special machinery because, after all, one must give the machine tool makers a chance to supply what was required. The machine tool makers had to solve the difficulties of many engineering firms and, naturally, they gained a very wide experience. Provided the machine tool makers did what he felt sure they must do in the future, i.e., employ the right type of salesman—the type of man who had a considerable knowledge of production applicable to the particular type of machine he was selling, and who was able to give his customers the benefit of his experience gained in supplying equipment to other firms, even though those firms were making different products—they were in a very fine position to submit really effective designs of equipment. With regard to single-purpose machines, it was not a sane policy to buy such machines unless the quantity of articles to be produced by them was sufficient to cover the cost of the machines. He congratulated Mr. Hancock on his remarks with regard to the training of the younger men in the planning department and urged production engineers, when visiting other factories for the purpose of examining the sequence of operations, the equipment, etc., to take with them a junior member of the planning department, to discuss matters with him, and to allow him to express his own views.

Mr. Hancock said that there is to his knowledge, a definite move in this country towards the standardisation of electric motors and motor parts. With regard to sending blue-prints of components to machine tool makers, he said that if one did not give the machine tool maker some knowledge of the work that his machine was asked to perform, one was throwing away the opportunity of securing the machine tool maker's assistance, and production engineers could not afford to do that. The simplest and quickest way in which to give the machine tool makers the necessary information was to send them a blue-print. He heartily agreed with the Chairman—as mentioned in the paper—with the importance of giving the juniors every possible opportunity of obtaining information, and considered the successful men in industry to-day, were those who gave their juniors the best opportunity to render assistance.

On the motion of Mr. Willmot, a hearty vote of thanks was accorded to Mr. Hancock.

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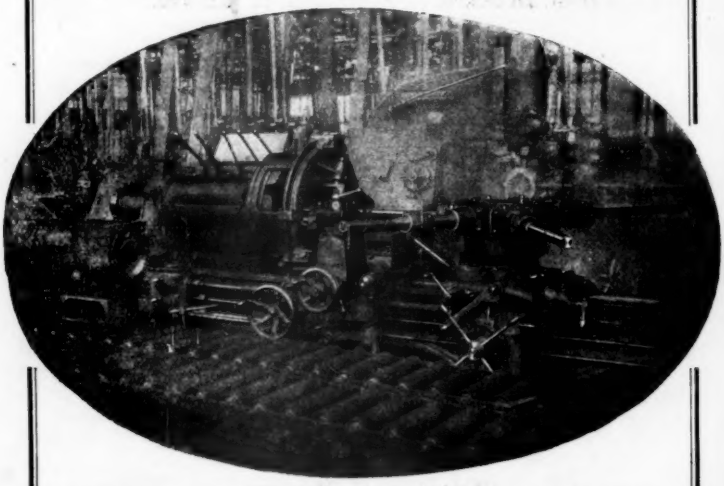
COMBINATION TURRET LATHES

on Line Production of Crank Cases



THE illustration shews a Ward No. 10 Combination Lathe as a unit in a modern lined out section for the production of combined cylinder blocks and crank cases. It is one of a pair of machines arranged for two processes covering the boring and reaming of the crankshaft bearing housings and facing and boring the ends. For the first process which is shewn on the photograph, the special barrel type jig is supported by means of a roller steady bracket attached to the bed of the lathe. Cylinders are delivered to the machines by means of a roller track.

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